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Economic Implications of Environmentally Smart System of Rice Intensification in Nigeria

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Abstract

Rice is a staple food in almost all parts of the world, especially Africa and Asia, as a rich source of carbohydrate. However, rice cultivation contributes greatly to climate change through the emission of greenhouse gases involved in soil and plant management, fertiliser application as well as water management practices.

While the environmental benefits of environmentally smart rice farming practices in Nigeria have been established, the same has not been for the economic implications of environmentally smart rice farming.

Prior to this study, there was inadequate information on the profit margins in different rice production systems in Nigeria. The research aimed at understanding and evaluating the method that gives a higher profit margin while having lesser environmental impact.

The study's primary sources of information require two distinct research methodologies and as such, two major types of data collection methods; qualitative and quantitative as suitable for participatory action research viz: questionnaire, focus group discussion, participant observation and key informant interview.

The research findings demonstrate that the environmentally-smart system of rice intensification is more profitable than the conventional method.

Keywords: climate smart agriculture, cost benefit analysis, rice, SRI, system of rice intensification

1. Introduction

1.1 Rice Farming in Nigeria

Nigeria is Africa's leading consumer of rice, producing about 7.3 million metric tonnes in mid-year 2019/2020 (USDA, 2019). The country is one of the largest producers of rice in Africa and simultaneously, one of the largest rice importers in the world. As well as an important food security crop, rice is an essential cash crop for its mainly small-scale producers who commonly sell 80% of total production and consume only 20%. Rice generates more income for Nigerian farmers than any other cash crop in the country. (FAO, 2020).

Rice is one of the major staple foods in Nigeria, consumed across all geo-political zones and socioeconomic classes in Nigeria (KPMG, 2019). There are growing concerns about the sustainability of our food production, especially since the rise of local food production and evidence of local, regional and global climate change.

Sustainable and environmentally-friendly ways of rice production can reduce its contribution to climate change. From water-saving nutrient management technologies and reducing fertiliser applications to sustainable waste management, the amount of emissions of greenhouse gases from rice fields and production plants can be reduced, lessening the impact of rice production on climate change.

1.2 Reasons for the Research

The purpose of the research is to develop a shared understanding of the economic implications of environmentally-smart rice production practices between the researcher and farmers to encourage the adoption of environmentally-smart rice farming practices as a way of reducing the negative impact of food production on the environment.

1.2.1 Research Hypothesis

This study assesses the economic implications of environmentally smart rice production in Emiworo Community, Kogi State. The research seeks to assert or refute the assumption that there are economic implications of adopting

environmentally sound practices in rice production, since a lot of people believe that environmentally - friendly options are usually not cost effective in business and even individual lives.

1.2.2 The Research Question

The research seeks to test the hypothesis: environmentally smart rice farming practices are more profitable than conventional rice farming practices. Through a reflective process, the key research question was further broken down into the following ancillary questions:

1) What are the economic benefits or otherwise, of the System of Rice Intensification (SRI) in Emiworo?
2) Are there any differences in the economic viability of the two systems of rice production?
3) What factors determine the adoption or otherwise of environmentally smart rice farming practices?

The findings will help to achieve the following objectives:

1) To assess the economic value of conventional rice farming.
2) To investigate the economic benefits of the System of Rice Intensification (SRI) in Emiworo.
3) To compare and contrast the economic viability of the two systems of rice production.

1.3 Rice Production Systems and Climate Change

1.3.1 Rice Production systems

Aside from the conventional method of rice farming which involves the use of chemical inputs, there are other methods of rice production.

1.3.1.1 Environment-Smart Agriculture (ESA)

ESA aims at sustaining increased agricultural production while limiting negative impacts on the environment (Sabiha and Rahman, 2018). ESA is concerned with environment-friendly farming practices that can potentially minimise on-farm environmental impacts for a given agricultural system. Compared to Climate Smart Agriculture (CSA), ESA considers a set of environment-friendly farming practices, which potentially exert a minimum level of impact on the farm environment for a given agricultural system, while CSA deals with farming operations at a comparatively larger scale.

ESA practices are concerned with limiting on-farm environmental impacts and sustainability in agricultural production at a local scale such as agricultural practices that can reduce greenhouse gas emissions, negative impacts on either soil or water resources or both, consistent use of excessive and overuse of chemical fertilisers contaminate soil and water bodies by emitting GHGs.

Mapping of interactions of the factors of environmental impacts is important and can be presented by environmental impact assessment. Sabiha and Rahman (2018) focused on these relevant aspects of evaluating the on-farm environmental impacts produced by chemical-intensive agricultural practices, which called for the need to practice ESA.

The results showed that "weeding is a near universal practice with only 3 cases (1% reportedly not weeding), each having applied herbicides at the time of land preparation. Weeding tends to be manual (75% of cases), with 41% using herbicides with backpack sprayers.

Fertiliser application to rice is relatively widespread in about 62% of rice fields. There is however, a marked difference over rice ecologies – fertiliser application being universal in irrigated rice fields, widespread in rainfed lowland fields and relatively uncommon in upland fields. Applied manually in a single dose and by broadcasting, most frequently used fertilisers are NPK (40% of rice fields) and urea (23%), with 5% of rice fields receiving unspecified fertiliser.

In pest control, half of the rice farmers reported practising some forms of bird control. The prevalent method (39% of surveyed rice fields) is manual bird scaring, whereas 11% reported using bird control structures, majorly scarecrows and the use of cassette/video tapes. Some forms of bird control are used in upland and irrigated rice fields, but are relatively rare in the lowland rice fields. This is likely to be related to the prevalence of floodplains in lowland rice surveyed – where the substantial rice areas involved are likely to diffuse bird damage incurred and increase the relative cost of bird control.

The survey highlighted that ***economic returns*** to conventional rice production are relatively limited. This implies a need to enhance productivity and reduce production costs to enhance competitiveness.

1.3.1.2 System of Rice Intensification (SRI)

The System of Rice Intensification (SRI) originated in Madagascar as a promising systemic approach to enhance rice production at affordable costs by reducing input requirements as well as causing less harm to the environment (Varma, 2019).

SRI is an agro-ecological methodology for increasing the productivity of irrigated rice by changing the management of plants, soil, water and nutrients (Selvaraju, 2013). It has been proven to be a path to sustainable rice production through reduced water requirements, increased land productivity, and promotion of less reliance on artificial fertilisers, pesticides, herbicides, and other agrochemicals. In addition, it buffers against the effects of climate change and reduces greenhouse gases (GHG). However, the decision to adopt SRI is a function of experience in terms of age, farm assets, irrigation facility and information about SRI from formal sources. Small and marginal farmers are more likely to adopt SRI (Varma, 2019).

SRI simultaneously raises the productivity of the land, water, and capital in irrigated rice by changing the management of plants, soil, water, and nutrients. The recommended SRI management practices for rice include:

- Transplanting rice seedlings when they are very young and spacing them farther apart on a regular grid rather than randomly. (This approach reduces crowding, strengthens root systems, and allows farmers to use manual weeders.)
- Using integrated pest management rather than using herbicides.
- Enriching soil with organic matter rather than inorganic synthetic fertiliser.
- Applying water intermittently rather than continuously flooding paddy fields.
- Using manual weeders to aerate topsoil and remove weeds.

This reduces the global warming potential of rice production, decreases air pollution from burning rice straw as well as rice production's share of freshwater use. It improves water governance for food security and decreases water pollution from rice-based production systems. It also helps to avoid soil degradation, improve soil health and increase biodiversity in rice landscapes.

1.3.1.3 "ES-SRI": Environmentally Smart - System of Rice Intensification

This study adopted some aspects of ESA in the SRI as the traditional SRI favours the use of chemical inputs in integrated nutrient management and pest control. The infusion of environmentally smart practices in the research necessitated the term *"ES-SRI" Environmentally Smart - System of Rice Intensification* adopted in this study. This approach was employed as sustainability implies not only economic sustainability, but environmental and social sustainability; the three pillars of sustainability.

1.3.2 Impacts of Rice Production on Climate Change

Rice farming pre-production includes inputs of farming systems such as agricultural pesticides, fertilisers and fuel. Its production stage refers to all phases associated with cultivation and harvest including sterilising seeds, ploughing rice fields, planting rice, spraying agricultural pesticides and fertilisers, harvesting, drying cereals, and polishing (Kim et al, 2018). From the foregoing, the conventional rice production system contributes to higher water losses through puddling, surface evaporation, and percolation (ADB, 2019).

While assessing the Analysis of the Effects of Direct Payment Subsidies for Environmentally-Friendly Agriculture on Income of Rice Farmers in Shiga, Japan, Santos and Shimanda (2019) revealed that environmentally-friendly agriculture has been promoted for over two decades as a response to the environmental challenges brought by climate change and biological loss. The approach was to explicitly determine the economic effects of the programme on income to determine how the gains from environmentally-friendly agriculture influence farmers' decision to adopt the practice.

For instance, in conventional farming which employs high levels of chemical inputs, higher yield is always associated with higher social costs due to more pollutants being discharged into the environment. By reducing the use of chemical pesticides and fertilisers to less than 50% of the conventional practice, proper use and management of compost and agricultural wastewater; the discharge of total nitrogen from agricultural lands to the Lake Biwa environment was reduced by 18.2% in 2015.

Conventional cultivation of rice would result in harvesting 1,034 kg/ha more than the environmentally-friendly cultivation. When the positive aspects were compared with the negative aspects, there was a positive difference per hectare per year, suggesting that cultivation of rice through environmentally-friendly agriculture was profitable and can generate a higher income for the farmers. The authors concluded that environmentally-friendly agricultural

practices can significantly reduce the external costs such as pollution load to the Lake Biwa ecosystem and increase farm income as well.

1.3.3 Profitability of Different Rice Farming Systems

1.3.3.1 Production Systems across Different Topographies

Chidiebere-Mark et al (2019) while studying the profitability of different rice production systems in Ebonyi state, Nigeria found that swamp production systems had the highest return per hectare (29.37%) followed by lowland production systems (20.10%) and upland production systems (13.03%) although poor access to production credit and climate change were constraints to rice production in the area.

"Rice farming using the swamp production system was profitable, followed by lowland and upland rice production systems", (p. 245) they concluded.

Prior to the study, there was inadequate information on the profit margins in different rice production systems in the state and constraints limiting farmers from investing more in rice production. The study examined the socio-economic characteristics of the farmers in different rice production systems in the study area based on the topography, input and expected output. They ascertained the production systems, rice varieties cultivated and the sowing methods; determined the costs and return of the farmers in different production systems. It also included the identification of the factors that constrain farmers in different production systems.

Majority of the respondents (62.2%) adopted the swamp production system, while 21.2% and 16.7% percent used lowland and upland production systems respectively. Meanwhile, the results of the distribution of the farmers on production systems used for rice cultivation showed that the majority of the farmers (81.67%) used nurseries in seeding, while 18.33% of the farmers used broadcasting (direct seeding) methods. Direct sowing of rice is reported to reduce labour cost by 30% and overall production cost by 40% (Mahmood 2002, cited in Chidiebere-Mark et al 2019).

In addition, the return on investment was 20.10% and 13.03% for both lowland and upland production systems respectively. This indicated a $20.10 return for every $1 spent in rice farming using a lowland production system and $13.03 return for every $1 spent in upland rice farming.

1.3.3.2 Economic Implications of System of Rice Intensification

(Kamal, 2017) analysed whether SRI is effective enough in delivering sustainable development to substantiate the uncertainty regarding its social, economic, and environmental implications. The Economic Analysis of the System of Rice Intensification by Durga and Kumar (2013), observed that the benefit-cost ratio was higher for SRI (1.70) than non-SRI farms (1.17) in South India.

The study of the greenhouse gas (GHG) emission also compared each rice growth stage, with all of the fields emitting CO_2 mostly during the panicle formation stage. During the vegetative stage, methane and nitrous oxide were mostly emitted by all of the plots; the drainage of water from the paddy fields after the vegetative stage resulted in decreased GHG in all of the plots (Sampanpanish, P., 2012). The lowest GHG emission rate for all stages was found prior to the harvest rice stage.

To reduce GHG emission from paddy field farming, farmers should be encouraged to discard organic waste instead of burning, decrease the carbon cycle in an organic form to slow organic decomposition and increase photosynthesis. This is in addition to improving soil quality by increasing aeration and draining water from the paddies at regular intervals. Organic fertiliser containing a low quantity of nitrate can replace chemical fertiliser while the application of organic fertiliser in paddy field farming would protect and conserve the environment through pollution prevention (Sampanpanis, 2012).

In South India, per hectare cost of cultivation is around five percent lower in SRI than the conventional method. (Anbarassan, Karthick, Swaminathan, and Arivelarasan, 2013)

In Nigeria, there is limited information on SRI. Although there was a comparative analysis of the System of Rice Intensification and the traditional system of rice production in Cross River State in 2013, the study focused more on the socio-economic factors affecting the adoption of SRI by farmers. To this end, this research specifically focuses on the economic benefits of ES-SRI, and a comparative assessment of the two economic systems of rice cultivation - conventional and environmentally smart methods.

1.4 Perception of Rice Farmers to Climate Change

Rice farming is a huge contributor to climate change and is also affected by climate change effects such as rising sea levels, salinity, temperature rise, drought and flooding. The result of Olanrewaju, Tilakasiri, and Oso, S. (2017)

in a study of Climate Change and Rice Production shows that drought and extreme rainfall consequent of climate change negatively affected rice yield in predominantly rain fed areas. This was during the period between 1966 and 2002 with drought having a much greater impact than extreme rainfall. The perceived causes of climate change include deforestation, bush burning and extreme use of agrochemicals in rice production which manifested as irregularity in rainfall patterns and increase in temperature.

While investigating the perception of farmers in the rural areas on climate change in the three distinct ecological zones of Ondo state, Nigeria, Thompson and Oparinde (2015) observed clearly that the farmers in the state did not have full understanding of the concept of climate change. It was recommended that government at all levels should sensitize the farmers on the concept of climate change in the state.

Achieving this requires the concerted efforts of the government, NGOs and private organisations to put in place programmes that can sensitise farmers on the concept of climate change to enable them have the right perception about climate change, which would enable them to adopt adequate adaptive measures. In line with this revelation, this research appraises the perception of rice farmers in the Emiworo rice farming community to climate change.

2. Methods

2.1 Research Design

The research design was precipitated by the nature of the elements of inquiry and the people directly involved in the research, as well as the beneficiaries of the research. As the research progressed, it witnessed some changes as a result of participation rate, time of cultivation and farmers' perception of research.

The research focused on two distinct farming methods: conventional and environmentally-smart, aimed at understanding and evaluating the method that gives a higher profit margin while having lesser environmental impact. Higher profit margin, by implication, improves the living standards of the people.

2.1.1 Quantitative and Qualitative Research

While qualitative research is the application of non-numerical data gathering methods to determine the meaning of particular attributes by category or rank, quantitative research is the scientific approach to measure variables which are thereafter analysed using statistical methods to understand the relationship between the variables observed.

To this end, both qualitative and quantitative variables were measured in the study, giving rise to the mixed use of both methodologies. Qualitative methodology uses the subjective approach of observation and interview to understand personal opinions, attitudes, beliefs and practices of farmers to environmentally-smart farming, the environmental impact of rice production and the quality of the grains at harvest of the two methods. On the other hand, the quantitative methodology applies mathematical and statistical methods of testing to determine the economic benefits of the environmentally smart method, and using the **cost-benefit ratio** to determine the system that is more economically viable.

The qualitative methodology is quite subjective as there exists individual differences and each person has unique opinions based on the knowledge available to them, their level of education and cultural beliefs.

2.1.2 Participatory Action Research (PAR)

Fekede (2010) opines that the paradigm chosen by a researcher can also be determined by the kinds of questions that help them to investigate problems or issues they seek to answer. PAR emphasises collective participation and action between the researcher and the people primarily working in, or affected by the situation in finding meaning to the practices in which they participate with a view to improving it.

MacDonald (2012) articulated that "In addition, PAR requires that people put the practices, ideas, and assumptions about institutions to the test, involves record-keeping, requires participants to objectify their own experiences, involves making critical analysis, and is a political process."

Rather than treating people as external to the study, PAR involves the actual beneficiaries of the research process as participants since they are regarded as just as capable of doing research as those with an academic grounding in research methodologies. (Plant, 2005).

The distinctiveness of PAR was elucidated by Baum, MacDougall, & Smith (2006). "Firstly, it focuses on research whose purpose is to enable action through a reflective cycle, whereby participants collect and analyse data, then determine what action should follow. The resultant action is then further researched and an iterative reflective cycle perpetuates data collection, reflection, and action as in a corkscrew action." (p. 854)

2.2 Participant Characteristics

Most of the farmers that participated in the survey were male (94.87%) and 5.13% females. 92.31% of the farmers were within the age range for the active population in Nigeria (18 - 60) while 7.69% were above 60 years of age. This revealed that most of the farmers were actively working on their farms. This is corroborated by the mean age of the farmers which stood at 42.94 years. Furthermore, the mean farming experience is 25 years, giving a group with diverse experience in the sector.

2.2.1 Emiworo: A Perfect Example of Riverine Serenity

Emiworo is a small community located off Ganaja, in Ajaokuta Local government of Kogi State. Located in a very quiet environment, the community is situated very close to Niger State and has over 2 000 inhabitants, most of whom are of the Fulani tribe. It also hosts the Lower Niger River Basin Development Authority (LNRBDA), a public institution which has among its core mandates, the development of irrigation agronomy in Nigeria. The organisation provided technical support for this research. The farmers in Emiworo inherited the vocation from their parents and as such, they are very grounded in rice farming. In addition to this, the topography of the community makes it suitable for both dry and wet season rice farming; enabling productivity all year long.

2.2.2 The Emiworo Rice Farming Community

Emiworo community enjoys the technical support of the Lower Niger River Basin Development Authority (LNRBDA) through its FADAMA project situated in the community. The farmers are predominantly indigenes of the community and they practise the conventional method of chemical-based rice farming. Being a riverine area, their source of water for rice plants is the Emiworo river, a tributary of the confluence of Rivers Benue and Niger that meet at Lokoja. In the words of the Area Manager of the LNRBDA "*they (the farmers) here practise the conventional method. Hardly would you see anyone who practises any other method.*"

The rice produced in the community is locally milled and sold to the residents of Lokoja, the Kogi State capital.

2.3 Sampling Procedure

2.3.1 Sampling Technique

Local rice farmers in Emiworo Community participated in the survey. Sampling was employed to reduce the number of participants (Taherdoost, 2016). As opposed to the non-purposive sampling method in which all eligible individuals have a chance of being chosen for the sample, purposive sampling was used. Purposive sampling allows the sample to be drawn from targeted populations, and tends to be cheaper and more convenient.

From the entire population of rice farmers in the community, the purposive sampling technique was used to draw two sampling frames: farmers practising the conventional method and those applying some aspects of environmentally-smart farming; who were very few. This method is favourable as it presents the low-cost, easy and time-efficient method despite its drawback of being subjective.

Thereafter, convenience sampling was used to select an adequate sample size of participants because they are often readily and easily available. This sampling method was chosen, being the least expensive, least time-consuming, and most reliable for an assured participation level. In my case, the participants were asked if they were "*interested in adopting a method of rice cultivation that gives more yield, favours early harvesting and healthy plant establishment/spacing, enhances soil fertility and waste management including pesticides and herbicides?*" This allowed for voluntary participation which encouraged a higher degree of commitment.

2.3.2 Sample Size

To avoid sampling errors or biases, an adequate sample size of 40 farmers were chosen as identified by Taherdoost (2016) order to generalise from a sample - 36 farmers practising the conventional system and 3 using some aspects of the SRI who were encouraged to try out the whole system with which the outputs were measured against the conventional system. One person opted out of the research for lack of interest.

2.3.3 Research Methods

Primary data was used for the entire study. This involved working directly with some staff of the Lower Niger River Basin Development Authority FADAMA Scheme, (LNRBDA-FADAMA Project) Lokoja Area Office, Kogi State. The rural farmers at Emiworo FADAMA Irrigation Project and staff of Vertex Rice, a rice processing company.

From Emiworo community, two major rice farming blocs were identified: the conventional method and those adopting different aspects of the SRI. Thereafter, six farmers using the conventional method were directly involved in the study while four adopting some aspects of the SRI were encouraged to try out the SRI exclusively.

Data was obtained from the participants through a series of unstructured and key informant interviews. The data included general information of the respondents such as age, educational level, family size, land size, number of years of experience and mode of training. Detailed information on production systems like cost of farming inputs, cultivation periods and output quantity were obtained as well.

Triangulation, a method of using multiple forms of data methods was applied in the research given the diverse nature of research questions and the type of data required to provide adequate responses to the questions. Another factor that necessitated different research methods is the unique characteristics of the participants we wanted to generate data from viz-a-vis their level of education, exposure and ability to articulate responses. Triangulation also helps to check the reliability of the different research methods used, giving the study more credibility.

3. Results and Discussions

3.1 Introduction

This section investigates the economic benefits of environmentally smart rice farming systems using the System of Rice Intensification. The economic benefits of both the SRI and the conventional methods are provided in the third section. It also compares the two methods to identify the one with a better return on investment using the Cost-Benefit Ratio.

3.2 Presentation of Research Results

3.2.1 Economic Benefits of System of Rice Intensification

Financial accounting analysis involving calculation of percentages and averages were carried out to interpret the data related to cost, returns, input use. Furthermore, the future costs were discounted by the current inflation rate in Nigeria (12%) to be able to appropriately compare the values of input costs and output costs using the Net Present Value (NPV). The result of the analysis gave a profit of 144.79% with a NPV of 338 861.61 NGN. Details of the analysis are presented in Appendix A.

Decision rule: If the calculated NPV for a project is positive, then the project is satisfactory, and if NPV is negative, then the project is not satisfactory. Since the present value of the profit is still higher than the present value of the input cost, the project is feasible.

3.2.2 Assessing the Economic Viability of the Two Systems of Rice Production

In order to better understand the economic advantage of SRI cultivation, a detailed economic analysis of the SRI method was done and compared with the conventional method in Appendix B. The analysis of the conventional method indicated a profit of 28.96% with a NPV of 280 506.25 NGN.

The decision rule of Mutually Exclusive Projects states that the project with the highest (higher in this case) would be chosen for execution. As seen in the analysis in Appendix B, SRI with a NPV of 338 861.61 NGN is higher than that of the conventional method at 282 614.29 NGN. Therefore, the System of Rice Intensification has higher economic returns and should be adopted.

3.2.3 Cost Benefit Ratio

A cost-benefit ratio (also known as a benefit-cost ratio) is a metric used to analyse decisions, systems or projects, or determine a value for intangibles. The model is built by identifying the benefits of an action as well as the associated costs, and subtracting the costs from benefits. The analysis yields concrete results (as seen in Appendix C) that can be used to develop reasonable conclusions around the feasibility and/or advisability of a decision or situation.

$$\text{Benefit-cost ratio} = \frac{NPV\ \ of\ \ B}{\text{NPV of C}}$$

Decision rule: If the benefit is higher than the cost of the project, it is a good investment. For mutually exclusive projects, the project with the higher ratio should be implemented. As evidenced from the analysis in Appendix C, both farming methods are profitable but the SRI has a higher Cost - Benefit Ratio and should be implemented.

3.2.4 Comparative Input Analysis of Conventional and SRI Farms

The expenditure incurred on each input was worked out for SRI and non-SRI farms separately and the results are presented in Table 1. It could be seen that in SRI, the major expenditure was incurred on labour wages, which accounted for 43.7% as against 23.18% in the conventional method.

It is worthy to note that in the SRI farms, the cost of seeds was of a lesser amount (21 667 NGN) as compared to the non-SRI farms (29 972 NGN) as a result of the reduction in seed rate in the SRI technology. However, the

percentage cost of seedlings in SRI (13.98%) is higher than that of the conventional method (12.30%). This is due to the planting of okra as a substitute to chemical pesticides.

It could also be noted that the share of cost on plant protection chemicals was lower in SRI than the conventional method; 20.64% and 42.68% respectively.

Furthermore, it could be observed that the cost of fertiliser was lesser in SRI (15.24%) than the conventional method (17.74%).

Total Costs

The cost of cultivation is presented in Table 1. The average total cost of cultivation per hectare was 155 042 NGN for SRI farms and 243 752 NGN per hectare for the conventional farms. The cost of cultivation was higher for non-SRI farms by 57.1%. The costs of cultivating the conventional farms were higher especially because of greater input costs required in the farming method.

Table 1.

Particulars	**SRI farm (%)**	**Conventional farm (%)**
Seeds	21 667 (13.98)	29 972 (12.30)
Manure	23 625(15.24)	------
Chemical Fertilisers	---------	43 250 (17.74)
Insecticides	10 000 (6.45)	4 800 (1.97)
Pesticides	22 000 (14.19)	60 480 (24.81)
Herbicides	----------	38 750 (15.90)
Labour	67 750 (43.70)	56 500 (23.18)
Water Supply	10 000 (6.45)	10 000 (4.10)
Total Cost of Cultivation	**155 042**	**243 752**

Returns

As expected, the SRI method of rice cultivation produced relatively higher yield when compared to conventional rice cultivation. The average yield of SRI cultivation is 3 756 kg/ha, which is 19.54% higher than the conventional method of rice cultivation (3 142 kg/ha). This is aside from the cost of okra which was grown as a biological control to ward off insects as against the use of chemical-based insecticides in the conventional method. "*This method is very good, never have I had this quantity of harvest since I started my farm*", said Mr Adogi.

Table 2.

Particulars	**SRI farm**	**Conventional farm**
Mean Grain Yield (kg/ha)	3,756	3,142
Price of Output (NGN/kg)	100	100
Income from Output (NGN/ha)	314 167	314 167
Income from Okra(Protective Crop) NGN	3 900	--------
Gross Income (NGN/ha)	379 525	314 167
Total Expenses (NGN/ha)	155 042	243 752
Net Income (NGN/ha)	224 483	70 595

This is what Uphoff (2015) described as the "super-yield" because the very high yields occasionally reported with SRI management are beyond what scientists have been able to produce in their on-station trials" (p. 21).

It could be observed from Table 2 that the gross income was estimated to be 314 167 NGN and 379 525 NGN per hectare respectively for SRI and non-SRI farmers. Thus, gross income is 82.78% higher for SRI farmers as compared to non-SRI farms. Further, it could be seen that the net income was higher for SRI (224 483 NGN) than

for non-SRI (70 595 NGN) farms. It was mainly due to the higher productivity of paddy in the SRI method.

It was also observed that the benefit-cost ratio was higher for SRI (2.45) than non-SRI farms (1.29). The SRI farms had increased productivity and thereby the returns in paddy crop were comparatively high. The increased grain yield under SRI was mainly attributed to a greater number of lengthy productive tillers which formed most of the input costs. Thus, the cumulative effect for SRI farmers was higher returns compared to non-SRI farmers due to less seed rate, elimination of pesticides and chemical fertilisers.

4. Discussions

Qualitative Analysis of the Conventional and Environmentally Smart Practices

Twenty (20) farmers voluntarily agreed to be participants of the survey. Data were collected about the household head's education level to capture effects such as the ability of households to adopt new technologies, as well as ability to better optimise farming and marketing practices. The survey also obtained information about the farmer's experience, which is expected to have a positive impact on farm profitability.

The socio-economic data obtained from the survey also include the number of children had, number of children in farming and farm size to determine the effect of the source of labour used on choice of farming practice.

Demography: The participants of the study were made up of 18 men and 2 women between the ages of 26 and 66 years. Of the 20 participants, 17 learnt the methods of rice farming informally while 3 studied agriculture-inclined courses at formal educational institutions. 17 of the 20 participants adopted the conventional method of rice cultivation while 3 used the environmentally smart methods of SRI.

Environmentally-smart options: 85% of the farmers that participated in the study have tried one or more aspects of SRI viz: hand weeding, organic fertiliser, plant spacing & transplanting, irrigation, biological insect control and traps & net pests.

5% of the respondents have used hand weeding rather than herbicides at some point of their work. 20% have used compost in place of chemical fertilisers while 3% apply plant spacing techniques on their farms. Irrigation is the most widely used out of the SRI options with 60% of the farmers using it especially during the dry season. 20% of the farmers also use the biological methods of pest control to replace the use of chemical insecticides by planting either maize or okra on the borders of the farm. This, they said, will stop the insects from invading the rice plants while also adding to the output of the farm at harvest.

40% of the farmers use traditional methods of local traps for animals and nets to avoid birds' invasion while 60% employ transplanting within two weeks of planting or soaking of seedlings overnight.

A greater number of the respondents (60%) have used one or more of the SRI options for not more than 5 years. 25% have used them for more than 5 years and 15% have not tried any of the options.

Rationale for/against choosing SRI:

Unavailability of rain for dry season farming was the reason 30% of the participants employed the irrigation option. The activities of the public institutions did not go unnoticed as 15% of the farmers responded positively to being educated by the Lower Niger River Basin Development Authority (LNRBDA) on irrigation and transplanting. In the words of Mr Sunday *"...like this issue of irrigation and transplanting, it was the agricultural extension (sic) officers of the Basin (LNRBDA) that brought it and it has been working*."

A good number of the farmers chose irrigation to be able to plant during the dry season without even attempting to plant during the rainy season for fear of flood as Kogi state is prone to flooding in the rainy season.

10% chose SRI because of the cheap cost of farming inputs involved. The effectiveness of pest control accounts for the use of SRI by 20% of the farmers coupled with an interesting case of a farmer that tried out some SRI options for his personal research and development.

On the other hand, 10% of the farmers have never used any of the methods of SRI. Another 20% have used it but discontinued because of the "*stressful and time consuming nature of the SRI*" as stated by Mohammed, one of the respondents.

The SRI Experience:

While about 20% of the farmers have never used any of the SRI methods, those who have used it shared their experiences which were analysed as follows:

Irrigation, especially for dry season farming increased the income of farmers as they would not have been able to plant after the rains. However, some of them (3 out of 20) expressed concern over the lower grain quality of

irrigation-based farming as compared to the rainfed rice farming. According to Mr Audu "*rice from irrigation has less weight than the one from rain-fed farming*."This was corroborated by the Production Manager of Vertex Rice, Mr Olasumbo. In his words "*the quality of irrigation rice farming as evidenced by the weight of the grain is lesser than that of rain-fed farming. It takes more grains to make up a bag of rice. Rice from irrigation gives less output than that of rainfed farming.*" When asked the likely reason for the difference, Mr Olasumbo said he wasn't clear about the reason. Being outside the scope of this study, I would recommend that further studies be carried out in that regard.

The biological method of insect control provides an opportunity for more income as it entails planting of okra or maize on the borders of each farm hectare to ward off insects' attack on the farm. This also generates more income at harvest as the plants would be harvested and sold in addition to the actual rice planted.

SRI provides an efficient pest control mechanism as most of the farmers using traps and nets responded positively to the efficacy of the traps.

Conversely, farmers who use manual weeding complained about the stress and labour involved in the method. From studies from other SRI systems in other countries, (Uphoff, 2015), I introduced the mechanical weeding machine to the farmers. This I hope will ease the arduous task of hand weeding particularly on large farms while aerating the soil.

From the output, we observed that the cow dung (organic manure) is as good as chemical fertiliser. However, it was not readily available. This was experienced firsthand while trying to get manure for the SRI trial farms. "*The Fulani herders do not know we now need it, so they did not pack it aside for us, the cow just pass faeces as they graze.*"These were the words of Parkwell, one of those encouraged to try out the entire system of ES-SRI. This situation is expected to change as there is more awareness of the demand of the cow dung in the area.

65% of the farmers did not believe that adopting SRI is capable of increasing the profits. 30% believed they can earn more from SRI while 5% had a level of uncertainty on whether or not it can be of economic benefit to them. Mr Audu who uses traps in place of pesticides says "*I understand I will make more money if they (pests) do not eat the crops but how will I earn from it*?"

Land clearing and labour costs remain the major hindrances to the implementation of SRI in Emiworo community. We observed that it was almost impossible to use manual land clearing on large farms and it consumed more time and labour than those who used conventional methods.

Other difficulties the SRI poses as a means of rice cultivation include the time consuming nature of frequent tending to SRI farms, laborious weeding and the uncertainty of the traps' efficiency.

60% of the participants were willing to try out SRI, another 20% were still undecided while the last 20% were not willing to try it out.

Challenges of conventional farming that encourage SRI: The high incidence of flood between May and October in Kogi state coupled with the high cost of insecticide and insect invasion. On the other hand, 30% of the farmers say they are totally satisfied with the conventional system.

Conclusion

The research findings demonstrate that the environmentally-smart system of rice intensification is more profitable than the conventional method. It also reflects that the continuous application of agrochemicals may damage the soil and cause decreased soil productivity and biodiversity, as well as increased pest attacks and methane emissions.

What remains to be assessed is if the dissemination of these results will lead to long term, sustainable behaviour change (Collier, 2009) or the farmers would go back to the conventional farming methods.

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Appendices

Appendix A: Cost Analysis of SRI (in Nigerian Naira)

	Seedlings	Manure (Cow Dung)	Water supply	Pesticide	Herbicide	Insecticide	Labour	Output (Rice) 100/kg	Okro
1	17 333	18 000	10 000	22 000	----	10 000	81 000	337 500	5 400
2	26 000	22 500	10 000	22 000	----	10 000	72 000	375 000	3 500
3	23 833	27 000	10 000	22 000	----	10 000	54 000	405 000	2 700
4	19 500	27 000	10 000	22 000	----	10 000	64 000	385 000	4 000
Average Cost	**21 667**	**23 625**	**10 000**	**22 000**	----	**10 000**	**67 750**	**375 625**	**3 900**

Total Average (Variable) Cost = 155 042 **Total Output = 379 525**

Profit (%) $= \frac{(SP-CP)\ x\ 100}{CP}$

$= \frac{(379\ 525\ -\ 155\ 042)\ x\ 100}{155\ 042}$

= 144.79% Profit

Net Present Value = A/ $(1+r)^t$

$= \frac{379\ 525}{(1+0.12)1}$

NPV = 338 861.61 NGN

Appendix B: Assessing the economic viability of the two systems of rice production.

Conventional:

	Seedlings	NPK	Liquid Fertiliser	Water supply	Pesticide	Herbicide	Insecticide	Labour	Output (N100/kg)
1	26 000	21 000	22 500	10 000	60 480	54 000	4 800	54 000	300 000
2	32 500	22 500	22 500	10 000	60 480	13 500	4 800	55 000	275 000
3	28 166	16 500	22 500	10 000	60 480	33 000	4 800	48 000	355 000
4	28 166	19 500	22 500	10 000	60 480	54 000	4 800	64 000	335 000
5	34 667	21 000	22 500	10 000	60 480	45 000	4 800	58 000	280 000
6	30 333	24 000	22 500	10 000	60 480	33 000	4 800	60 000	340 000
Average Cost	**29 972**	**20 750**	**22 500**	**10 000**	**60 480**	**38 750**	**4 800**	**56 500**	**314 167**

Total Average Cost = 243 752 **Average Output = 314 167**

Profit (%) $=\frac{(SP-CP)\ x\ 100}{\mathrm{CP}}$

$= \frac{(314\ 167\ -\ 243\ 752)\ X\ 100}{243\ 752}$

= 28.96% Profit

Net Present Value = A/ $(1+r)^t$

$= \frac{314\ 167}{(1+0.12)1}$

NPV = 280 506.25 NGN

Appendix C: Cost Benefit Ratio

Benefit-cost ratio = $\frac{NPV\ of\ B}{NPV\ of\ C}$

Conventional:

Benefit-Cost Ratio = $\frac{PV\ of\ Benefit}{PV\ of\ Cost}$

PV of Benefit = A/ $(1+r)^t$

$= \frac{314\ 167}{(1+0.12)}$

= 280 506.25 NGN

PV of Cost = A/ $(1+r)^t$

$= \frac{243\ 752}{(1.12)1}$

= 217 635.71 NGN

Benefit-cost ratio = $\frac{PV\ of\ B}{PV\ of\ C}$

$= \frac{280\ 506.25}{217\ 635.71}$

= 1.29

SRI:

Benefit-Cost Ratio = $\frac{PV\ of\ Benefit}{PV\ of\ Cost}$

PV of Benefit = A/ $(1+r)^t$

= $\frac{379\ 525}{(1.12)1}$

= 338 861.61NGN

PV of Cost = A/ $(1+r)^t$

= $\frac{155\ 042}{(1.12)1}$

= 138 430.36 NGN

Benefit-cost ratio = $\frac{PV\ of\ Benefit}{PV\ of\ Cost}$

= $\frac{338\ 861.6}{138\ 430.36}$

= 2.45